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ENGINEERING-SCIENCE, INC.

1700 Broadway, Suite 900 • Denver, Colorado 80290 • (303) 831-8100 • Fax: (303) 831-8208

August 3, 1994

Mr. Marty Faile
AFCEE/ERT
8001 Arnold Drive
Brooks AFB, Texas 78235-5357

RE: AFCEE Bioventing Test Initiative Final Tables

Dear Marty:

Please find attached final tables and site figures for several sites at which 12 months of bioventing pilot testing have been completed. Specifically, final tables and site figures are attached for Hickam AFB, Hawaii - Area H, Area K, and Site 2 at the Waikakalaua Fuel Storage Annex.

Please call me or Brian Blicher at (303) 831-8100 if you have any questions.

Sincerely,

ENGINEERING-SCIENCE, INC.



Doug C. Downey, P.E.
Project Manager

c.c.: Brian R. Blicher
File

AQM01-01-0291

DEFENSE TECHNICAL INFORMATION CENTER
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Laura Peña

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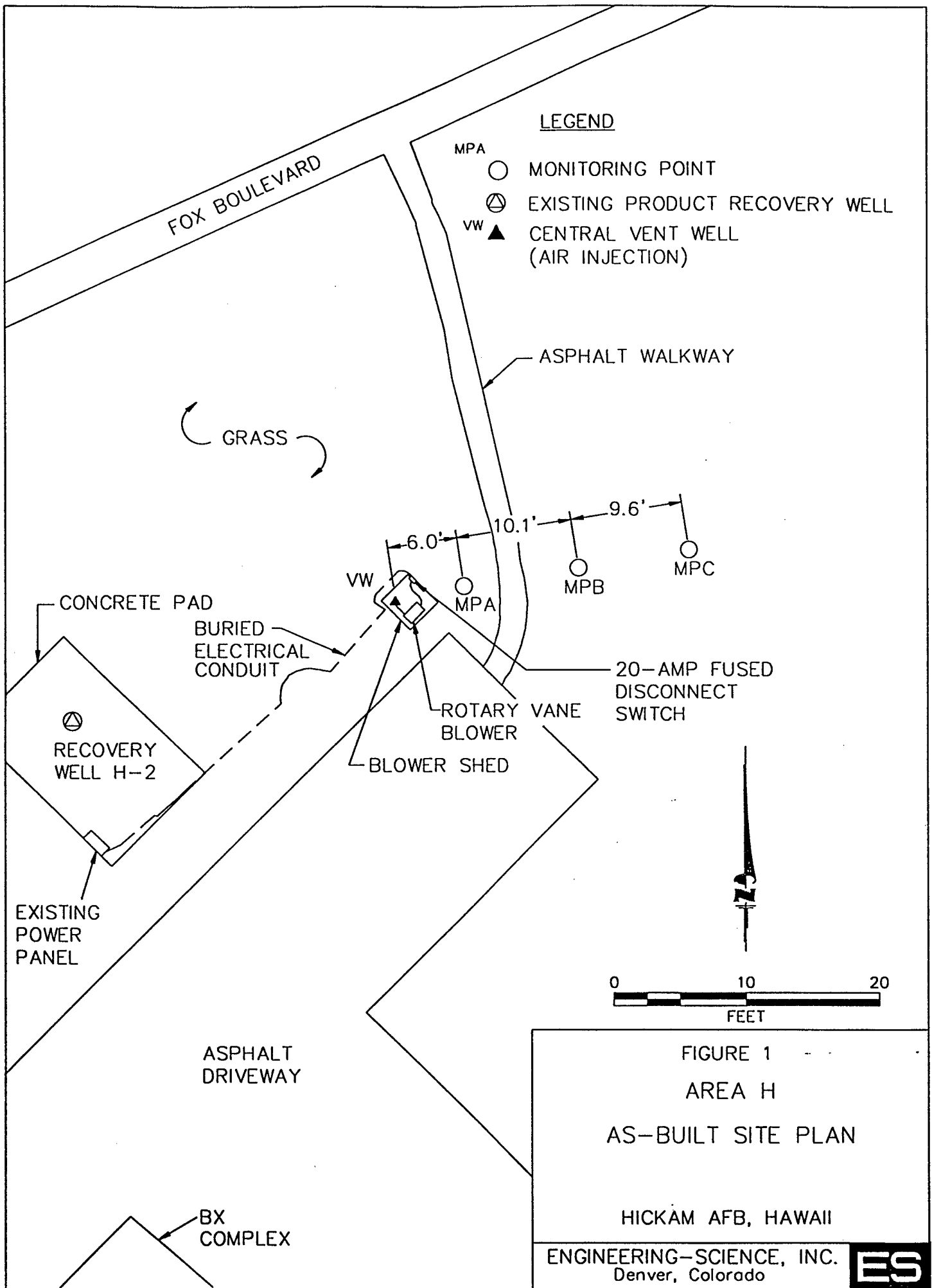


TABLE 1
AREA H
RESPIRATION AND DEGRADATION RATES
HICKAM AFB, HAWAII

Location - Depth (feet bgs) ^{a/}	Initial = April 1993			6 - Month ^{c/} = Nov. - Dec. 1993			1 - Year = May 1994		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW	0.020	<10 ^{e/}	NS ^{d/}	0.00032	<10	NS	0.00023	<10	NS
MPA-6	0.0043	210	26.7	0.00011	<10	32.0	0.00023	<10	28.6
MPA-12.3	NS	NS	NS	0.00046	19	NS	0.00030	<10	NS
MPA-16.5	NS	NS	26.3	0.0031	120	28.6	NS	NS	27.3
MPB-6.3	NS	NS	NS	0.000064	<10	NS	0.000031	<10	NS
MPB-16.5	NS	NS	NS	0.0052	52	NS	NS	NS	NS
MPC-12.4	0.011	110	NS	NS	NS	NS	NS	NS	NS

^{a/} feet bgs = feet below ground surface.

^{b/} Milligrams of hydrocarbons per kilogram of soil per year.

^{c/} Assumes moisture content of the soil is an average between the initial and final readings.

^{d/} NS = Not sampled.

^{e/} Although oxygen utilization was measured in these points, high levels of soil moisture are reducing the air-filled porosity of the soil and limiting oxygen supply to soil bacteria.

TABLE 2
AREA H
INITIAL AND 1 - YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HICKAM AFB, HAWAII

Analyte (Units) ^{a/}	Sample Location – Depth (feet below ground surface)					
	VW		MPA-6		MPB-6.3	
	Initial ^{b/}	1 – Year ^{d/}	Initial	1 – Year	Initial	1 – Year
Soil Gas Hydrocarbons						
TVH (ppmv)	330,000	210	2,100	6.9	NS ^{d/}	1.2
Benzene (ppmv)	<10	<0.003	<0.10	<0.002	NS	<0.002
Toluene (ppmv)	<10	0.020	<0.10	<0.002	NS	<0.002
Ethylbenzene (ppmv)	26	0.018	0.15	<0.002	NS	<0.002
Xylenes (ppmv)	<10	0.014	0.11	<0.002	NS	<0.002
					380,000	<10
					<10	57
					61	NS
Soil Hydrocarbons						
	VW-18		MPA-18		MPB-18	
	Initial ^{d/}	1 – Year ^{d/}	Initial	1 – Year	Initial	1 – Year
TRPH (mg/kg)	<5	<6.7	23.9	7.7	9.0	<6.5
Benzene (mg/kg)	2.25	0.06	<0.22	0.043	6.0	0.13
Toluene (mg/kg)	8.7	0.0014	1.2	0.032	6.0	0.0063
Ethylbenzene (mg/kg)	6.3	0.0014	2.0	0.0069	8.1	0.0064
Xylenes (mg/kg)	16.0	0.001	2.6	0.0099	4.0	0.0028
Moisture (%)	25.3	25.2	22.2	23.8	26.4	23.2

^a TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

b/Initial soil gas samples collected on April 22, 1993.

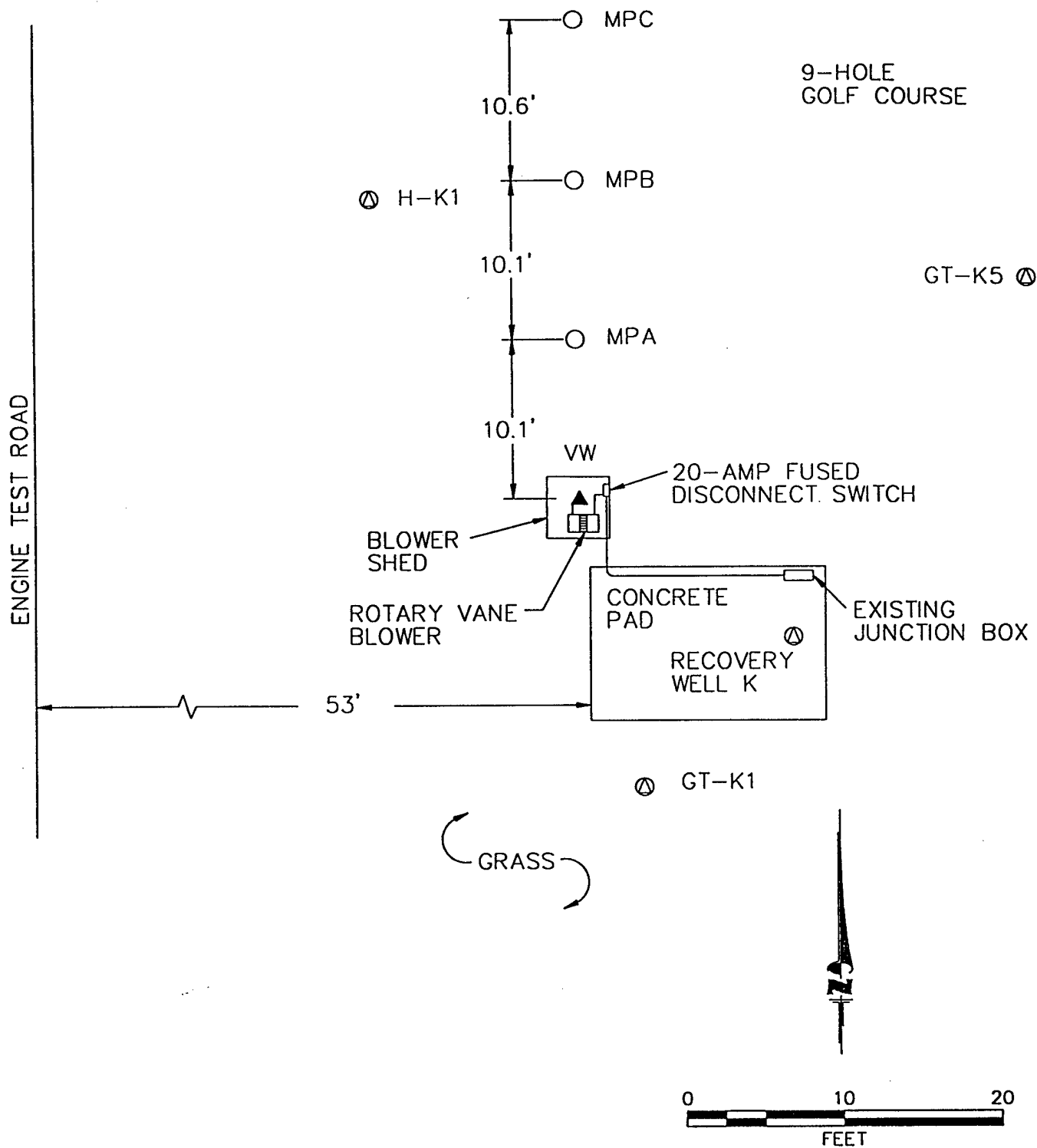
c/ 1 - Year soil gas samples collected on May 18 and 21, 1994.

d/NS = not sampled.

e/ Sample could not be collected due to presence of water at the screen.

f/ Initial soil samples collected on March 23 and 24, 1993.

g/ 1--Year soil samples collected on May 31 and June 1, 1994.



- LEGEND
- ⊙ EXISTING WELLS
 - VW ▲ CENTRAL VENT WELL (AIR INJECTION)
 - MPA ○ MONITORING POINT

FIGURE 1
AREA K
AS-BUILT SITE PLAN

HICKAM AFB, HAWAII

ENGINEERING-SCIENCE, INC.
Denver, Colorado

ES

TABLE 1
AREA K
RESPIRATION AND DEGRADATION RATES
HICKAM AFB, HAWAII

Location - Depth (feet bgs) ^{a/}	Initial = April 1993			6-Month ^{c/} = Nov.-Dec. 1993			1-Year = May 1994		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
MPA-5	0.026	5000	26.1	0.0062	1100	31.8	0.0072	1400	28.5
MPB-5	0.013	1800	NS ^{d/}	0.0092	1600	NS	0.0057	1100	NS
MPC-5	0.022	3300	NS	0.0071	1300	NS	0.0063	1200	NS

^{a/} feet bgs = feet below ground surface.

^{b/} Milligrams of hydrocarbons per kilogram of soil per year.

^{c/} Assumes moisture content of the soil is the average of the initial and 1-year soil moisture values.

^{d/} NS=Not Sampled.

TABLE 2
AREA K
INITIAL AND 1 - YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
HICKAM AFB, HAWAII

Analyte (Units) ^{a/}	Sample Location - Depth (feet below ground surface)					
	VW		MPA-5		MPC-5	
	Initial ^{b/}	1 - Year ^{c/}	Initial	1 - Year	Initial	1 - Year ^{d/}
Soil Gas Hydrocarbons						
TVH (ppmv)	4,000	17	41,000	45,000	34,000	2,600
Benzene (ppmv)	3.5	<0.01	130	<0.05	120	<0.05
Toluene (ppmv)	<0.2	<0.01	<2.0	<0.05	<2.0	<0.05
Ethylbenzene (ppmv)	2.7	0.073	41	3.3	22	2.6
Xylenes (ppmv)	14	0.24	81	9.0	48	6.7
Soil Hydrocarbons						
	VW-6.5		MPA-5.5		MPB-5.5	
	Initial ^{e/}	1 - Year ^{f/}	Initial	1 - Year	Initial	1 - Year
TRPH (mg/kg)	<5.0	66	<5.0	6.5	55	69
Benzene (mg/kg)	0.54	<0.0005	<0.83	<0.0005	2.2	<0.0005
Toluene (mg/kg)	5.9	<0.0005	6.5	<0.0005	23	<0.0005
Ethylbenzene (mg/kg)	2.6	<0.0005	6.4	<0.0005	21	<0.0005
Xylenes (mg/kg)	13	<0.0007	12	<0.0008	32	<0.0008
Moisture (%)	15.1	11.8	15.9	14.5	15.4	14.7

^{a/} TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;

TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil gas samples collected on April 2, 1993.

^{c/} 1 - Year soil gas samples collected on May 23, 1994.

^{d/} Results averaged with duplicate sample.

^{e/} Initial soil samples collected on March 24 - 25, 1993.

^{f/} 1 - Year soil samples collected on May 31, 1994.

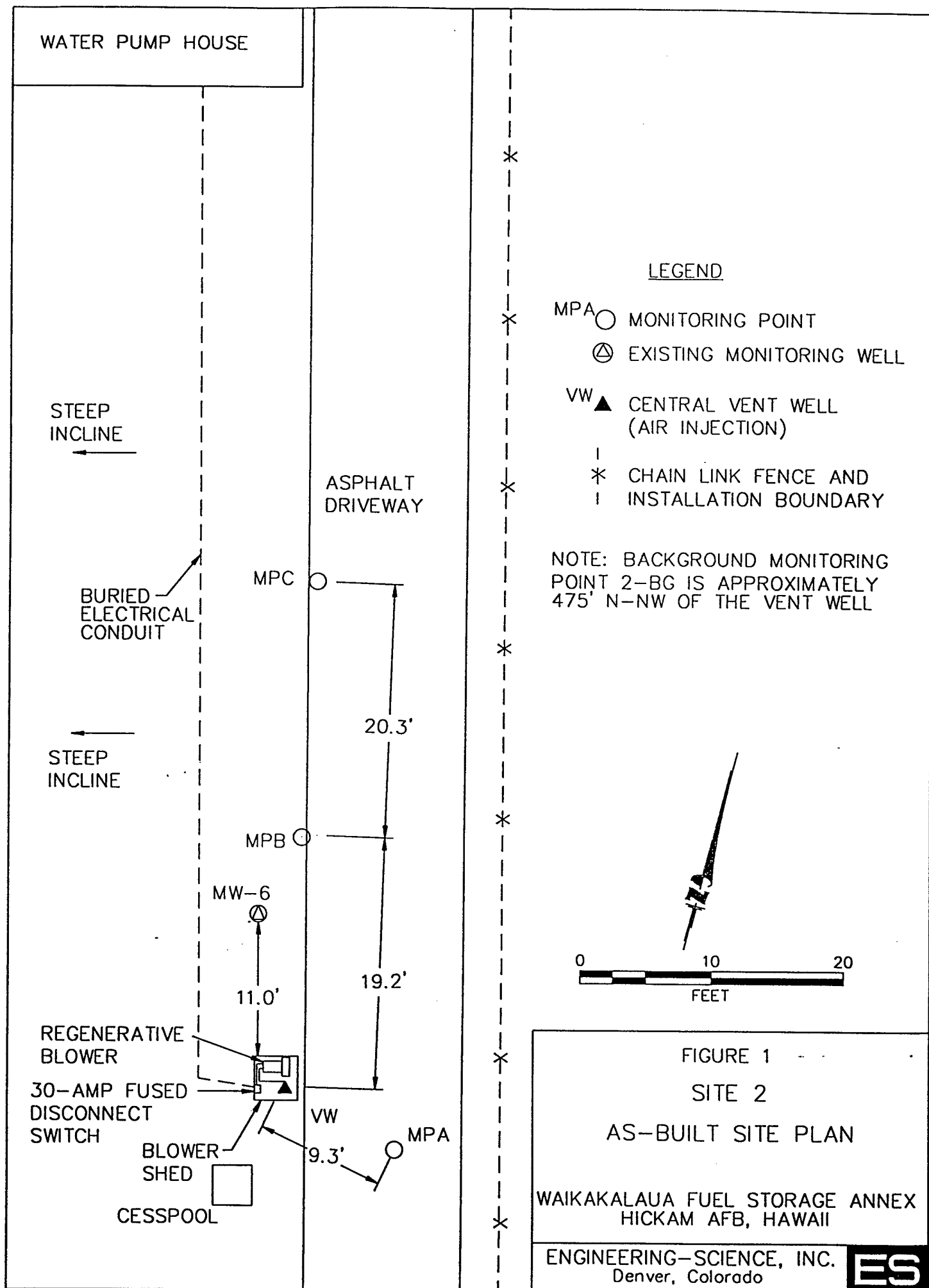


TABLE 1
SITE 2
RESPIRATION AND DEGRADATION RATES
WAIKAKALAU FUEL STORAGE ANNEX
HICKAM AFB, HAWAII

Location - Depth (feet bgs) ^{a/}	Initial = May 1993			6 - Month ^{c/} = Nov. 1993			1 - Year = May 1994		
	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year) ^{b/}	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)	K _o (% O ₂ /min)	Degradation Rate (mg/kg/year)	Soil Temperature (°C)
VW	0.0040	350	NS ^{d/}	0.00036	20	NS	0.0025	110	NS
MPA - 12.4	NS	NS	22.4	NS	NS	25.4	NS	NS	26.4
MPA - 24.3	0.017	890	NS	0.013	1600	NS	0.011	2300	NS
MPA - 70	NS	NS	26.2	NS	NS	25.1	NS	NS	25.6
MPB - 36.1	0.0010	<10 ^{e/}	NS	NS	NS	NS	0.0018	100	NS
MPC - 73.2	NS	NS	NS	0.00018	<10	NS	NS	NS	NS
MW - 6	0.018	1130	NS	NS	NS	NS	0.020	1600	NS

^{a/} feet bgs = feet below ground surface.

^{b/} Milligrams of hydrocarbons per kilogram of soil per year.

^{c/} Assumes moisture content of the soil is an average between the initial and final readings.

^{d/} NS = not sampled.

^{e/} Although oxygen utilization was measured in these points, high levels of moisture are reducing the air - filled porosity of the soil and limiting oxygen supply to soil bacteria.

TABLE 2
SITE 2
INITIAL AND 1-YEAR SOIL AND SOIL GAS ANALYTICAL RESULTS
WAIKAKALAU FUEL STORAGE ANNEX
HICKAM AFB, HAWAII

Analyte (Units) ^{a/}	Sample Location - Depth (feet below ground surface)					
	VW		MPA-24.3		MPC-37.6	
	Initial ^{b/}	1-Year ^{d/}	Initial	1-Year ^{d/}	Initial	1-Year
Soil Gas Hydrocarbons						
TVH (ppmv)	19,000	1.9	22,000	16,000	250	3,200
Benzene (ppmv)	46	<0.005	<1.1	<0.26	0.083	<0.11
Toluene (ppmv)	86	<0.005	<1.1	<0.26	0.450	<0.11
Ethylbenzene (ppmv)	16	<0.005	21	17	0.180	5.3
Xylenes (ppmv)	52	0.017	66	44	0.580	11
Soil Hydrocarbons						
	VW-29.5		VW-60		MPA-40	
	Initial ^{e/}	1-Year ^{f/}	Initial	1-Year ^{d/}	Initial	1-Year ^{d/}
TRPH (mg/kg)	51.76	3,540	3,586	135	553.1	1,842
Benzene (mg/kg)	<0.52	<3.9	1.7	1.5	<0.54	0.28
Toluene (mg/kg)	5.1	<3.9	3.6	10.7	4.5	1.3
Ethylbenzene (mg/kg)	8.1	33	0.85	5.3	6.5	4.7
Xylenes (mg/kg)	40	<5.5	4.1	26.6	31	20
Moisture (%)	32.6	36.6	33.4	32.5	34.8	24.3
					38.5	33.9

^{a/} TVH = total volatile hydrocarbons; ppmv = parts per million, volume per volume;
TRPH = total recoverable petroleum hydrocarbons; mg/kg = milligrams per kilogram.

^{b/} Initial soil gas samples collected on April 27, 1993.

^{c/} 1-Year soil gas samples collected on May 26, 1994.

^{d/} Results averaged with duplicate sample.

^{e/} Initial soil samples collected on March 30 to April 15, 1993.

^{f/} 1-Year soil samples collected on June 1 to 3, 1994.